Transport of radionuclides from the Japanese nuclear accident: mass hysteria or serious concern?

Dan Jaffe

Unit 4 of the Fukushima Dai-ichi nuclear plant on March 15th, 2011. Image from TEPCO via CBS News

Radiation levels in Tokyo, March 15th, 2011. Image from CBS News.

Acknowledge contributions from Wash. Dept. of Public Health and UW Physics!

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Japanese Earthquake, Tsunami and Nuclear Accident

A tragic natural disaster.

The Japanese people deserve our highest level of assistance, prayers and respect for carrying on in the face of a massive and complex multi-faceted disaster.

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Timeline

- March 11, 0546 GMT: Magnitude 9.0 earthquake strikes Japan approximately 350 km north of Tokyo. Within one hour, a wall of water up to 10 meters high hits the Japanese coast. Massive loss of life and injuries results. Millions without shelter and power.
- 1300 GMT: Cooling system at Fukushima plants reported to have failed. Evacuations of residents with 3 km of the plants.
- 1900 GMT: Radiation levels reported to be rising at Fukushima. Reactor intentionally vented to avoided pressure buildup. Nuclear emergency declared a few hours later. Situation deteriorates steadily for several days….
- March 12, 0900 GMT: First of a series of explosions that certainly released radiation. Evacuation extended out to 20 km.

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Timeline

- Saturday March 12: I start getting calls from reporters. At first I chose not to make a statement since there really wasn't anything to say, but then with the urging of Vince Stricher (UW press office) we decided to write a press release saying the risk in the US was extremely low. Media interest ramps up as the nuclear emergency gets worse.
- March 16th: UN Comprehensive Test Ban Treaty Organization releases first model suggesting long-rage transport of radionuclides to the US. Published in New York Times.
- March 18th: UW Nuclear Physics group detects fission products in air (confirmed by WA DOH).
- April 5th: Norwegian Institute for Air Research (NILU) model showing "plume" of radionuclides aimed straight at PNW.

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Selected news reports on radiation transport

- **How long would Japanese radiation take to reach Seattle?**
Cliff Mass Weather Blog, March 13th 2011

- **Nuclear crisis spikes sales of anti-radiation iodine pills**
Chicago Tribune, March 15th, 2011

- **Scientists Project Path of Radiation Plume**
New York Times, March 16, 2011

- **Radiation from Japan: How big a risk for U.S.?**
CBS News, March 16th, 2011

- **How concerned are you about nuclear fallout?**
CBC News, March 16th, 2011

- **Obama reassures: Japan's radiation won't reach US***
Seattle Times, March 17th, 2011

- **Japan Radiation Makes Way to U.S.**
USA Today, March 29, 2011

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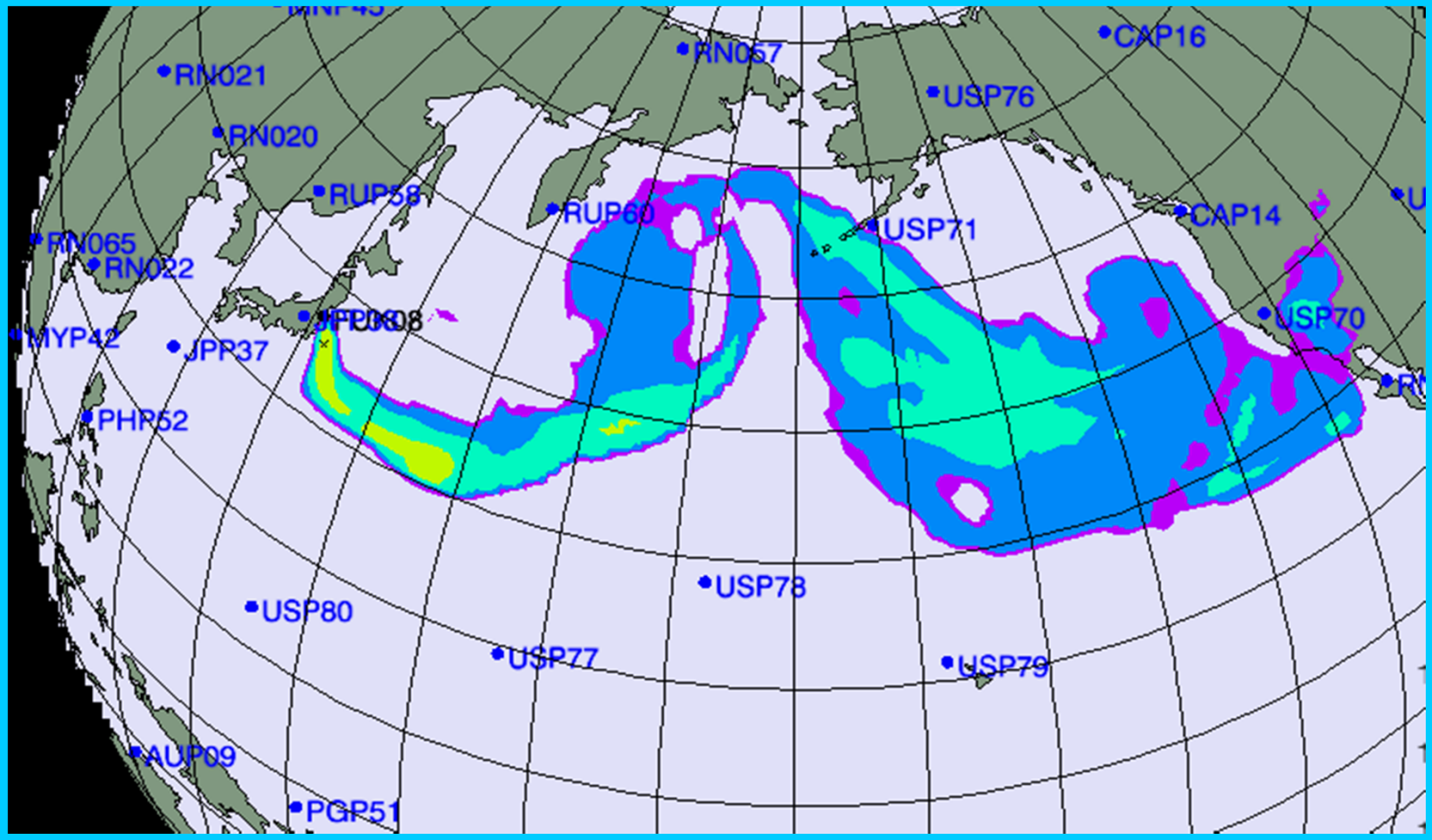
UN Comprehensive Test Ban Treaty Organization model of Radionuclides from Fukushima plant.



Published in New York Times on 3/16/2011.

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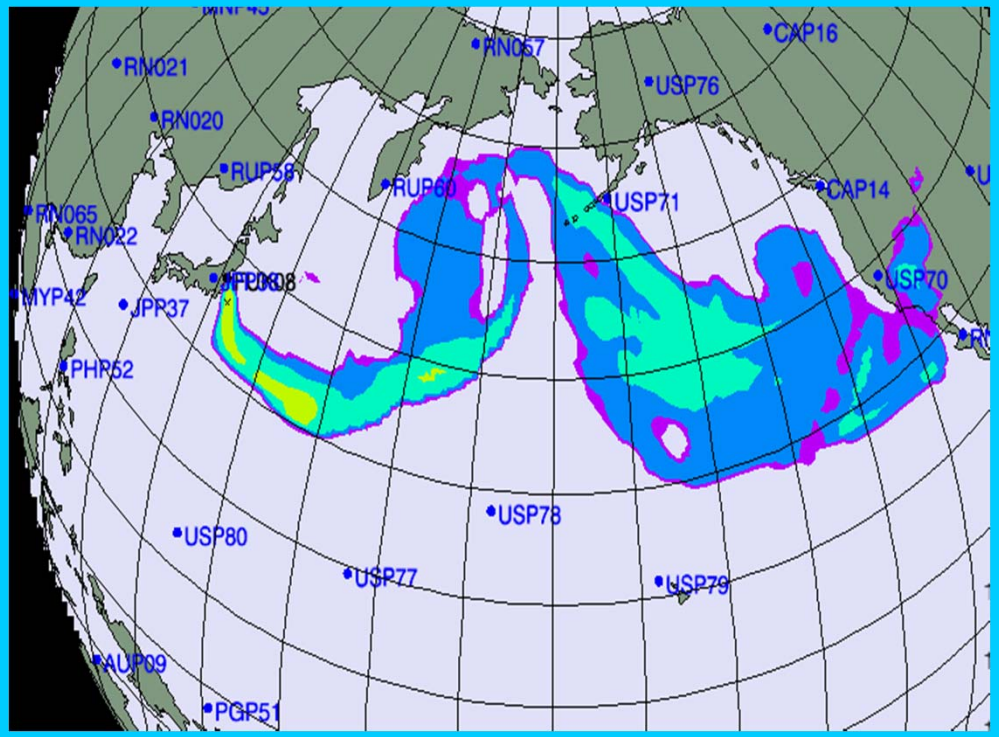
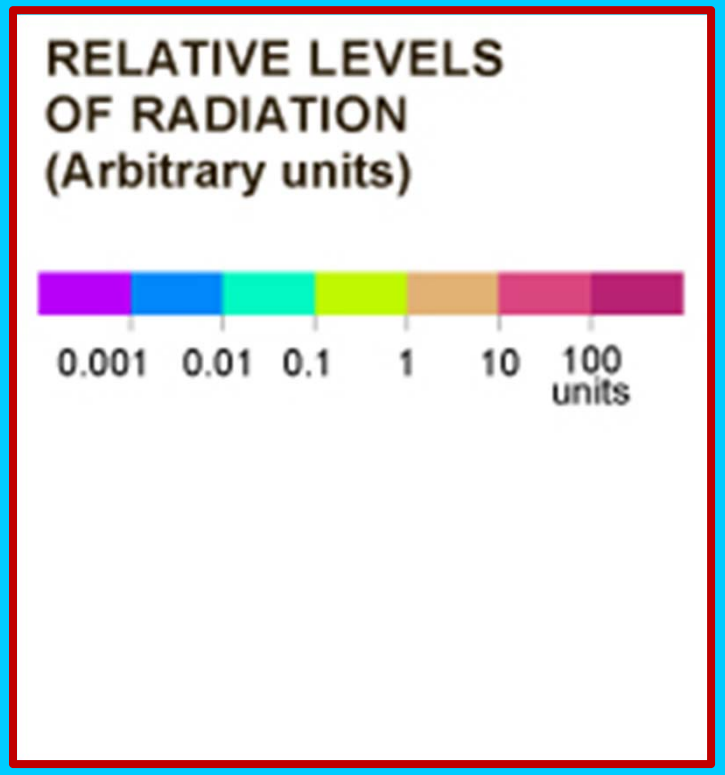
UN Comprehensive Test Ban Treaty Organization model of Radionuclides from Fukushima plant.





Model results released by UN Comprehensive Test Ban Treaty Organization. Published in NYT on 3/16/2011.

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Another widely circulated “forecast” with extremely high values…..

This map supposedly came from the “Australian Radiation Service”, but was later identified as a hoax or at least a seriously misleading figure.

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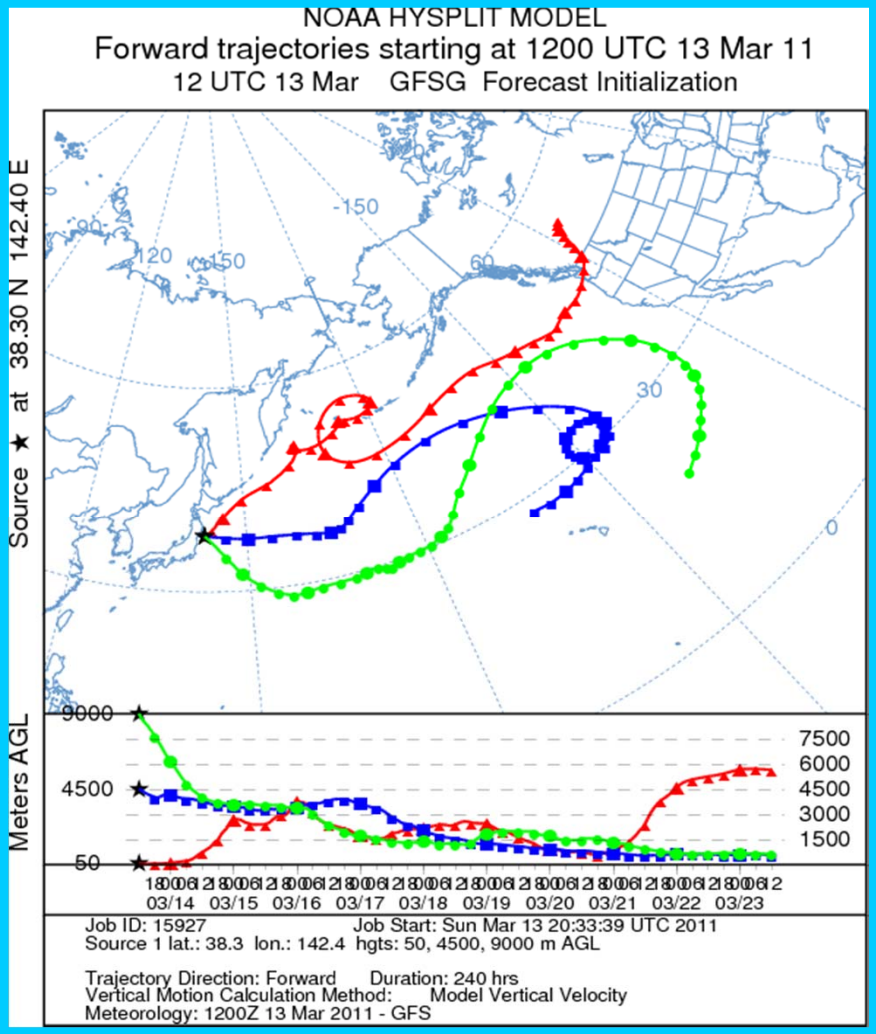
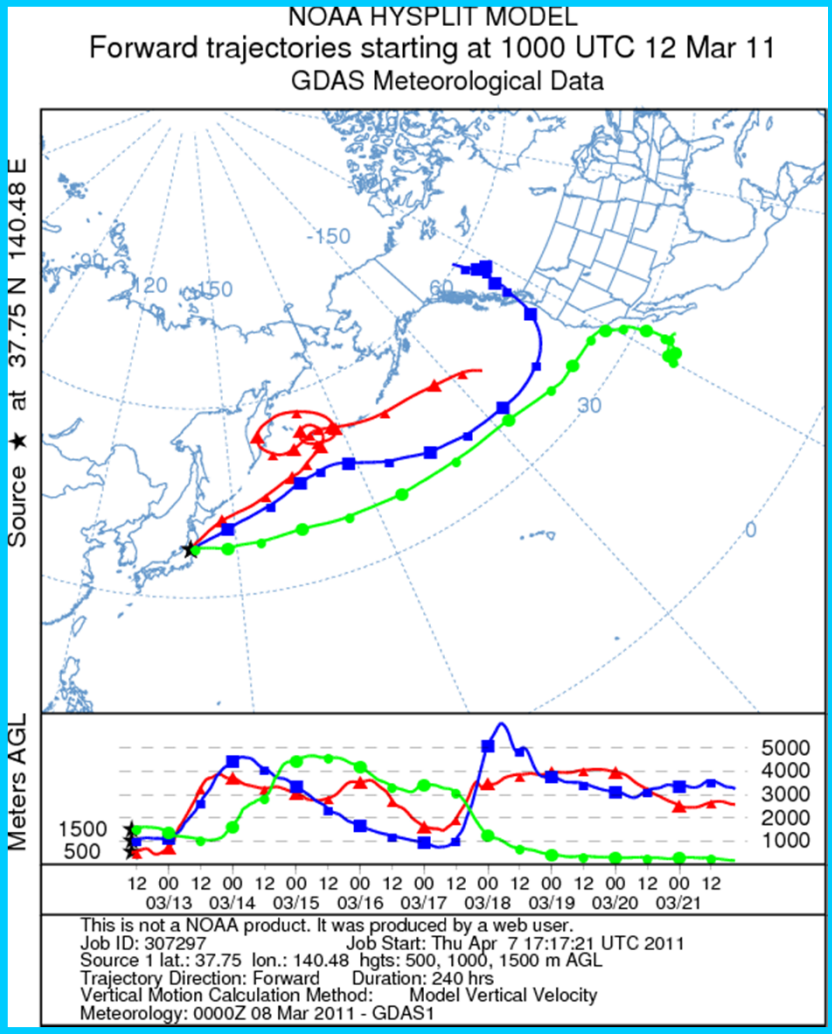
Hysplit trajectories suggest transport in 6-9 days





But how to translate this into a specific estimate of risk?

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Some challenges of applying science to the problem

- Radionuclides were being released, but we had no idea of the source term.
- Public did not understand the difference between a model forecast and reality.
- We needed some way to quantify possible impacts of radioactivity here.
- I used concept of dilution factor to explain the extremely low risks from radiation in the US.
- Dilution factor = Ratio of concentration in 20 km “grid cell” around Fukushima to worst case concentration seen in the US.

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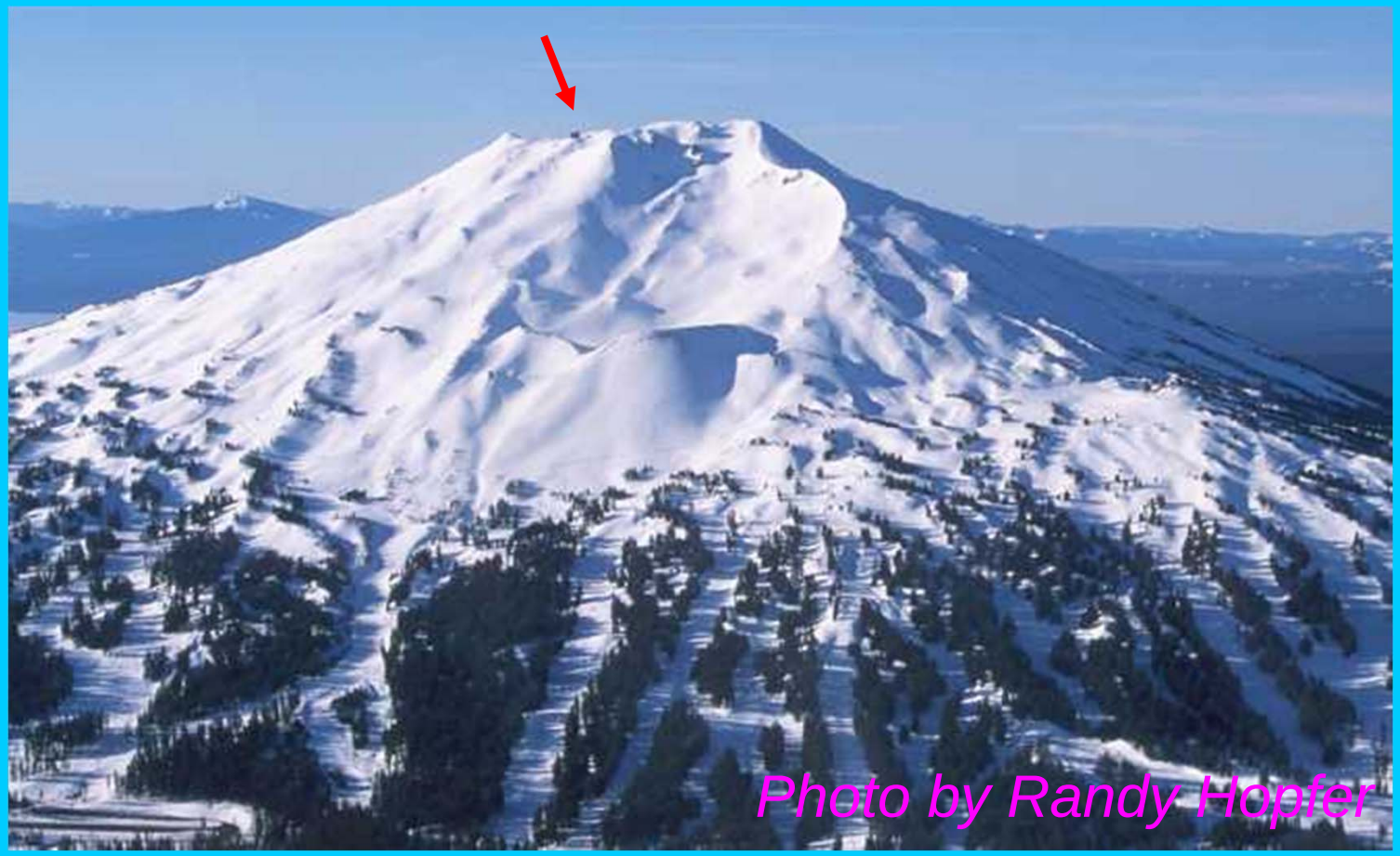
Mt. Bachelor, Oregon, 2.7 km above sea level



Only high elevation/free tropospheric atmos. research site in western U.S. Regularly samples Asian air pollution. Many papers on these results (CO, Hg, PM, O3, etc).

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Dilution factor

- Observations of long range transport of Asian pollutants to the PNW suggest a range of dilution factors:
- Asian BL → PNW Free troposphere (Mt Bachelor) 100:1
  e.g. 10 ppm CO →100 ppbv enhancement
- Asian BL → PNW BL

  1000:1 e.g. 10 ppm CO →10 ppbv enhancement
- But these represent dilution from huge area sources (eg thousands of power plants). The dilution from a single point source must be far lower.
- I estimated dilution factors of 10^4 -10^6. This means that the radiation exposure in PNW will be at least 10,000 times lower than any exposure seen in Japan and probably closer to a million times lower.

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Observations

- There were observations in Japan and around the US as part of EPA's Radnet network. There were also independents measurements at UW, UC-Berkeley and WA DOH.
- Near Fukushima, substantial radiation doses were measured in real-time following the accident.
- In the US real-time data (gross beta and gamma) were all below detection limit.
- Filter and charcoal cartridge collections with offline analysis by gamma-ray spectroscopy found specific radionuclides both in Japan and the US. Strongest detection of I-131, but also detection of Cs-137 and other radionuclides.
- Workers and some nearby residents had significant exposures. Exposure in Tokyo about 10% of background. Exposure in Seattle about <1% of background.

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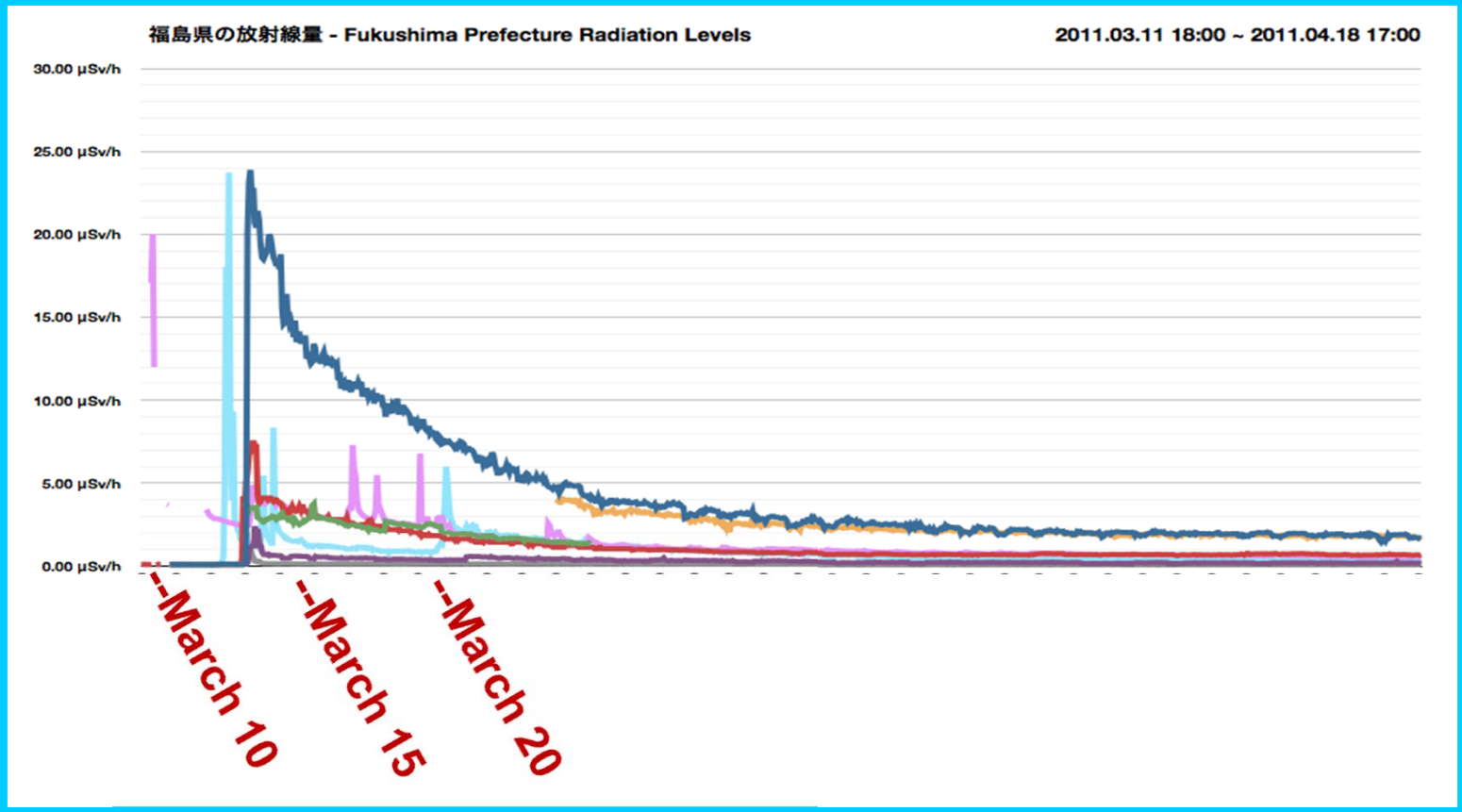
Fukushima area source (dose in uS/hr)



- **Observations of radionuclides started later, roughly 3/20. Maximum reported values of I-131 are in the 1000-6000 Bq/m3 range.**
- **Values in the US were undetectable with real time sensors.**
- **Data from Japanese MEXT (www.mext.go.jp/english/)**
- **Graph from fleep.com**

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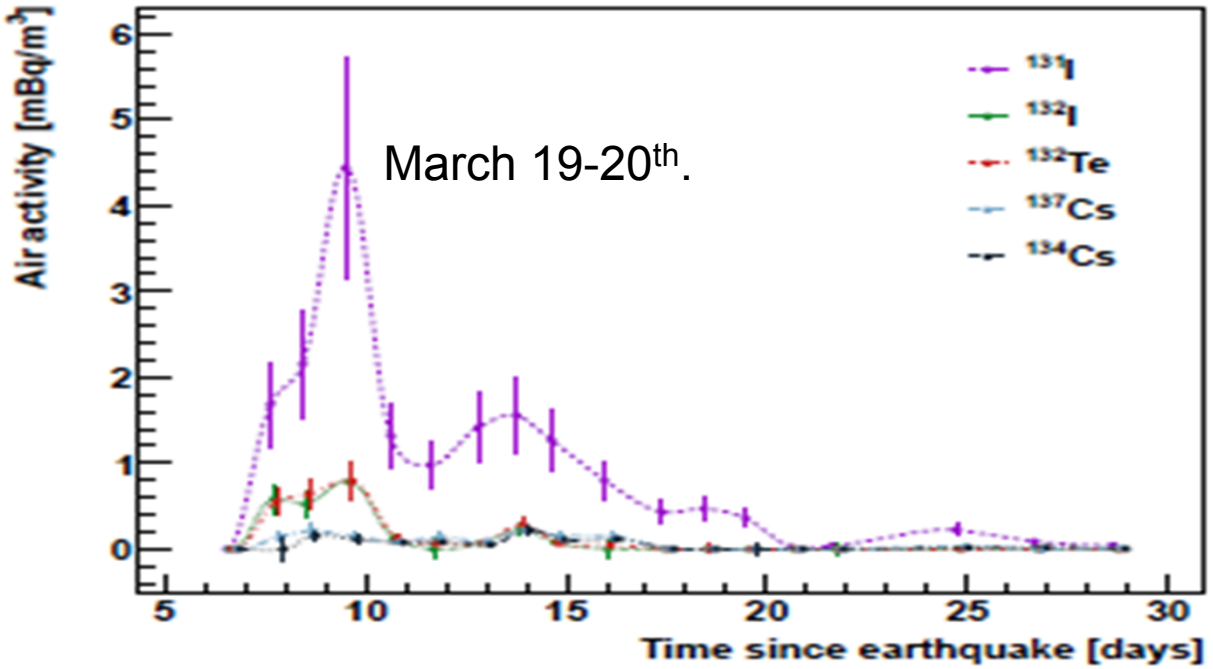
UW Physics data (hvac filters)



"Arrival time and magnitude of airborne fission products from the Fukushima, Japan, reactor incident as measured in Seattle, WA, USA" Leon J.D., D. A. Jaffe, J. Kaspar, A. Knecht, M. L. Miller, R. G. H. Robertson, and A. G. Schubert. Manuscript submitted to Atmos. Chem and Phys. Discussions, April 2011.

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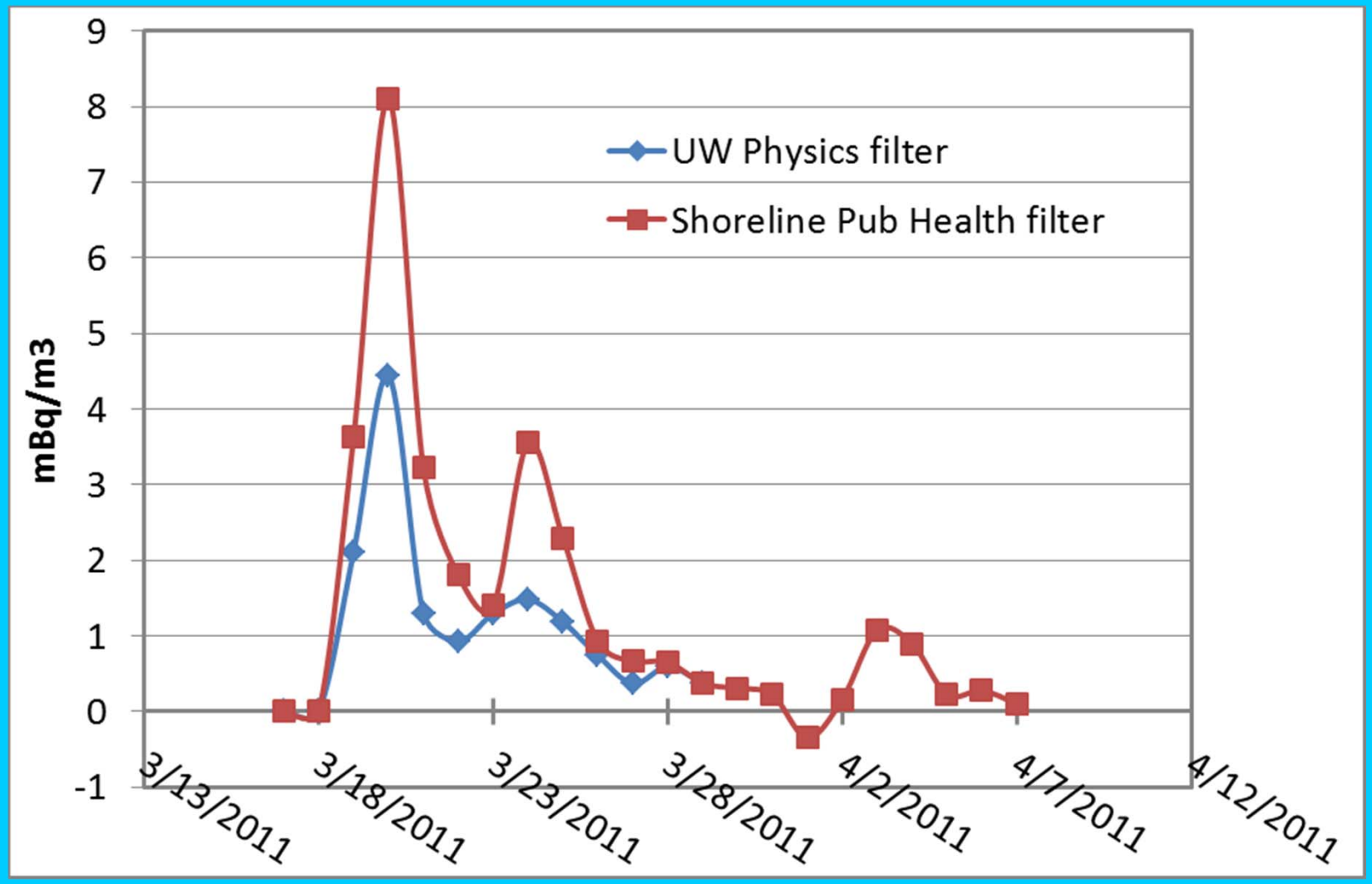
Detection of I-131 in Seattle area



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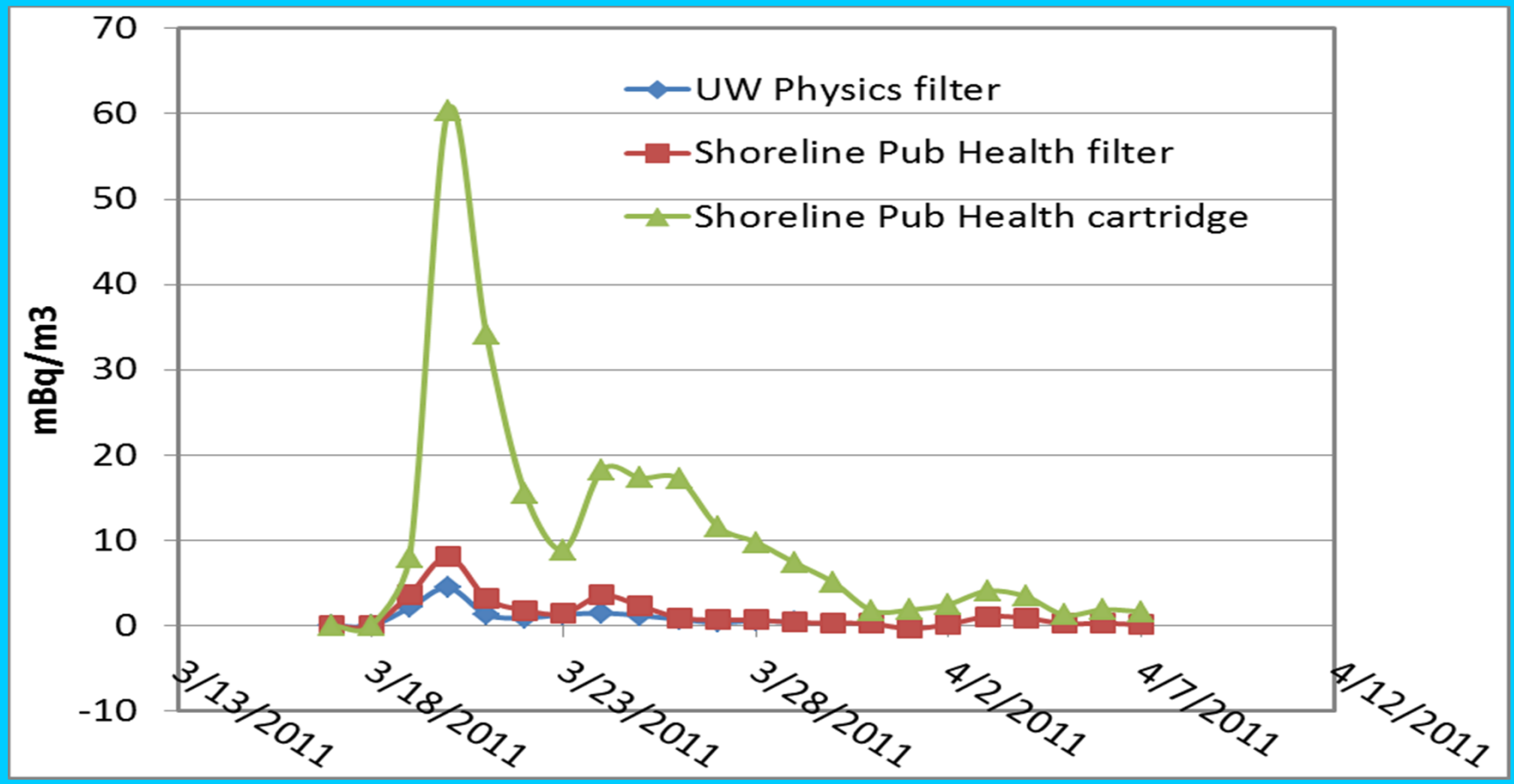
Detection of I-131 in Seattle area



Charcoal cartridges collected roughly 10x more than filters. This indicates that the majority of I-131 was in gas phase. This was further confirmed by more than 30 same day/same location samples by EPA Radnet.

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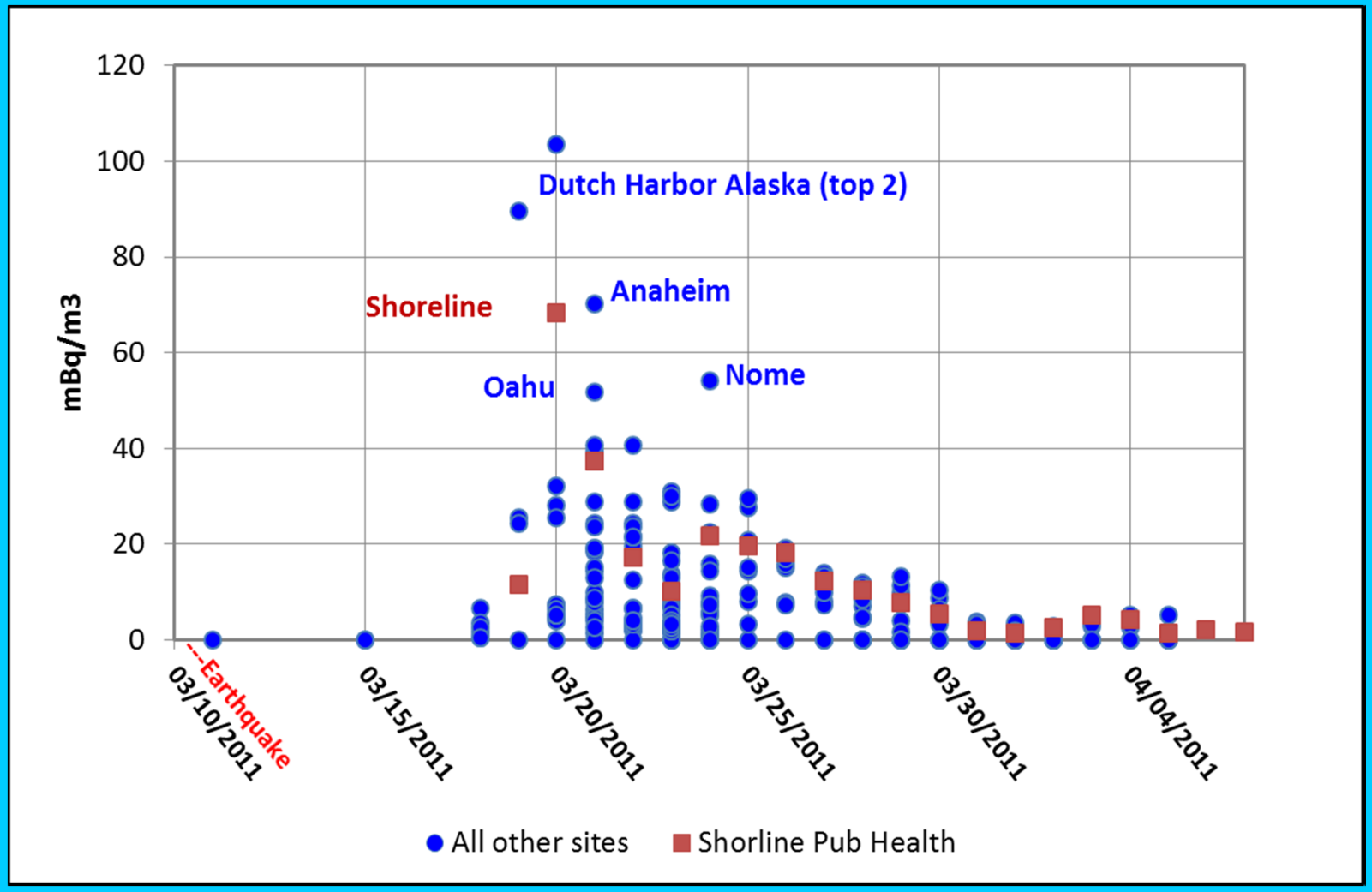
EPA's Radnet data: I-131 Cartridge samples



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Peak values for I-131 in Japan and the US

Location	Date	Bq/m3	Sample type
Fukushima region (25 km S of reactor)	3/21/2011	5600	Uncertain (probably charcoal)
Fukushima region (30 km WNW of reactor)	3/20/2011	3800	Uncertain (probably charcoal)
Dutch Harbor, AK	3/20/2011	0.104	Charcoal cartridge samples
Shoreline, WA (WA Public Health Lab)	3/20/2011	0.068	Charcoal cartridge samples

Taken at face value, this suggests dilution factors of 10^4-10^5. But note that there were no radionuclide measurements in Japan before 3/20/2011, It's likely that the concentrations were 3-4x higher. So the actual dilution factor is probably in the range of 10^5-10^6.

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Summary

- **The earthquake/tsunami/nuclear accident was a major tragedy for Japan.**
- **Significant levels of radiation were released as a result of the accident.**
- **The radionuclides were diluted by at least 10^5-10^6 during transport to the US so that no levels of concern were seen in the US.**
- **As scientists we have a level of expertise that may be called upon at any time. Thinking about how to communicate clearly with the public via the media is an important skill that should be taught to all science students.**
- **And now for my favorite headline….**

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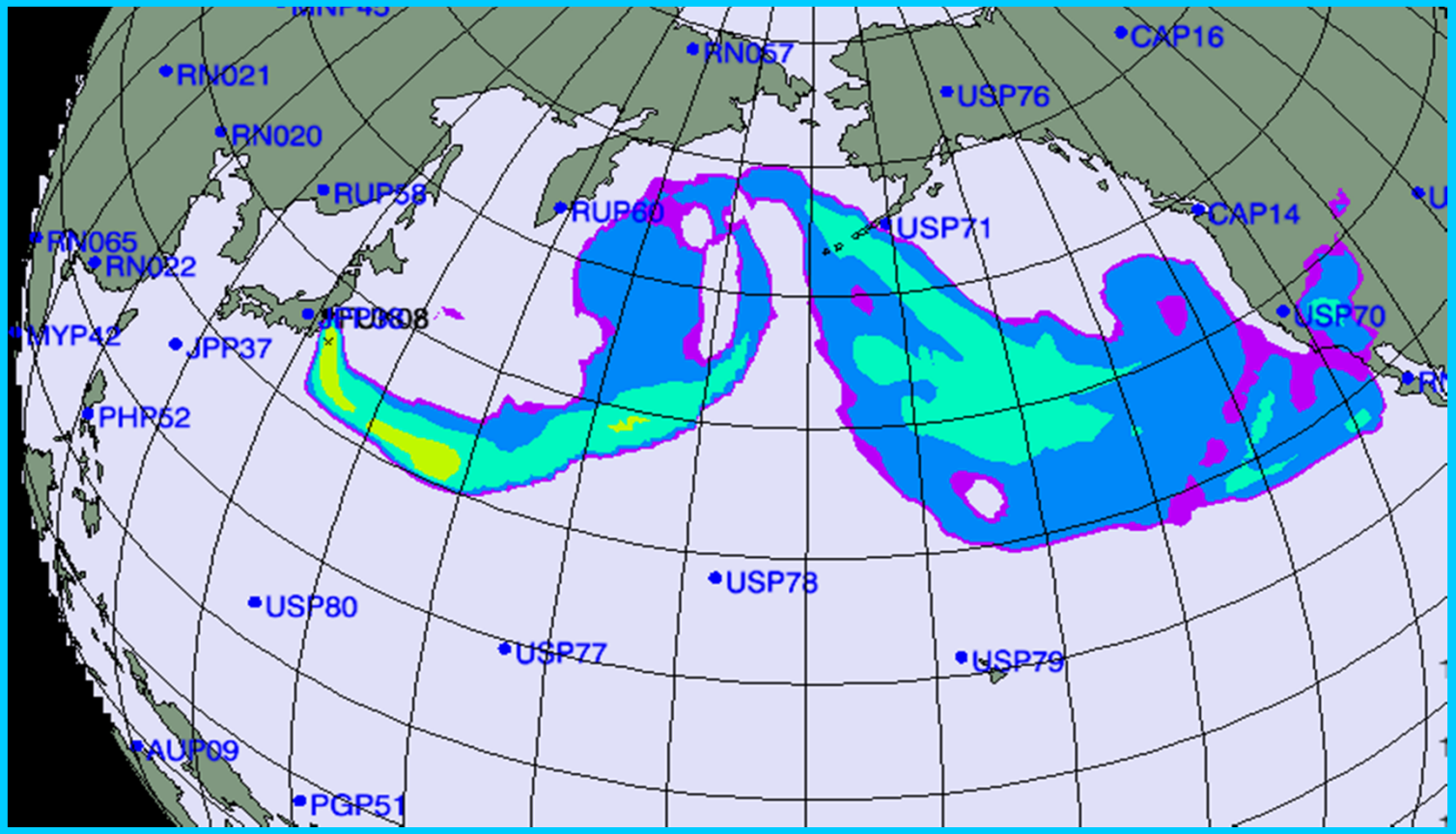
“Massive Radiation Cloud Headed towards Washington

UW meteorologists C. Mass leaves country to avoid radiation”



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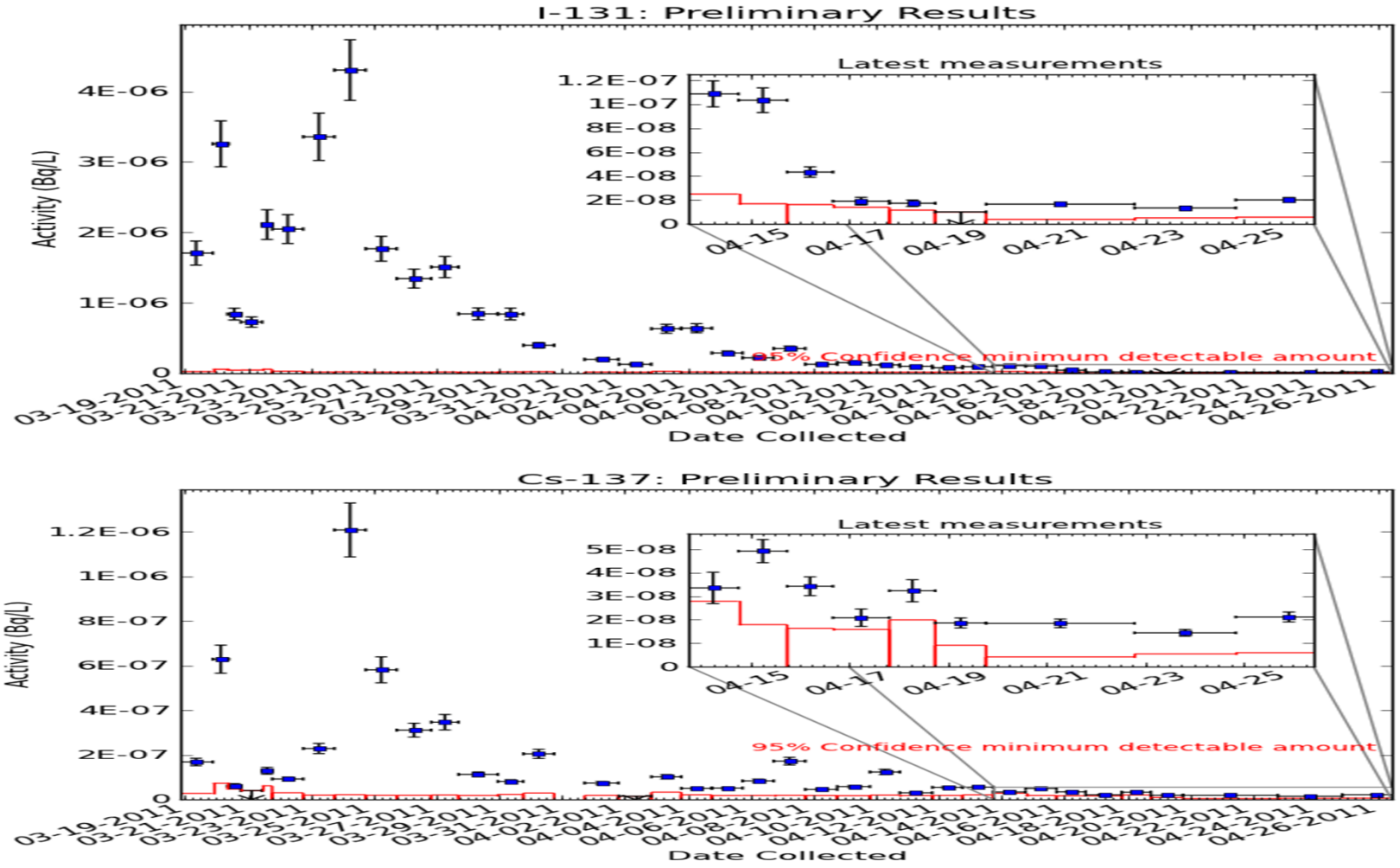
Extra slides

UC Berkeley data



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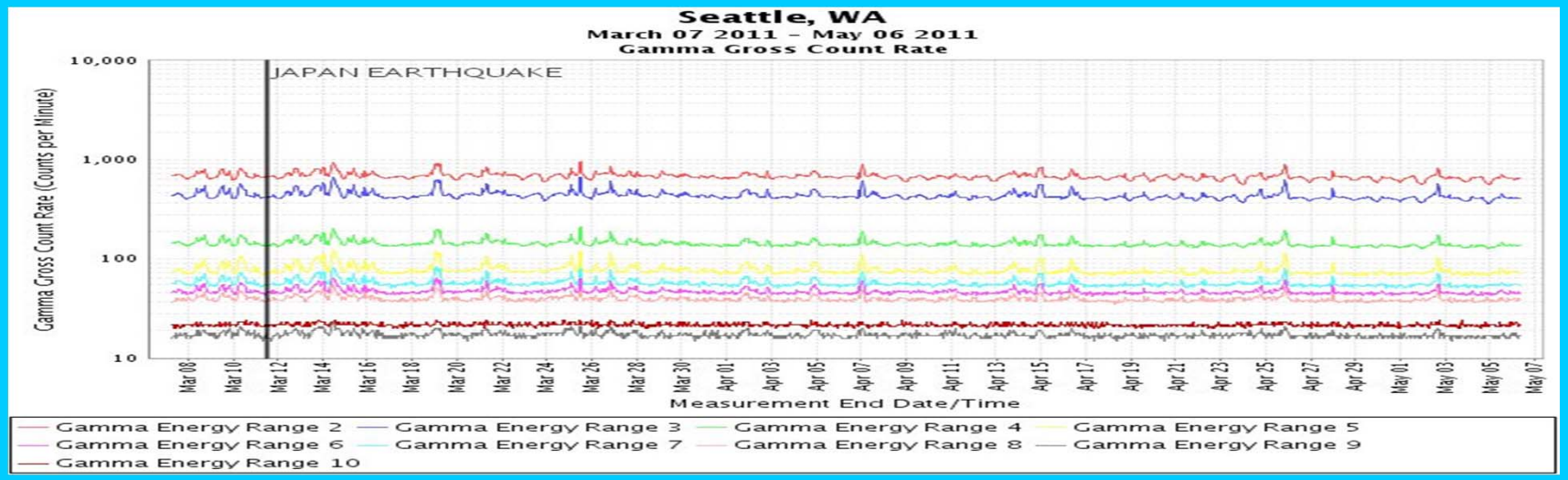
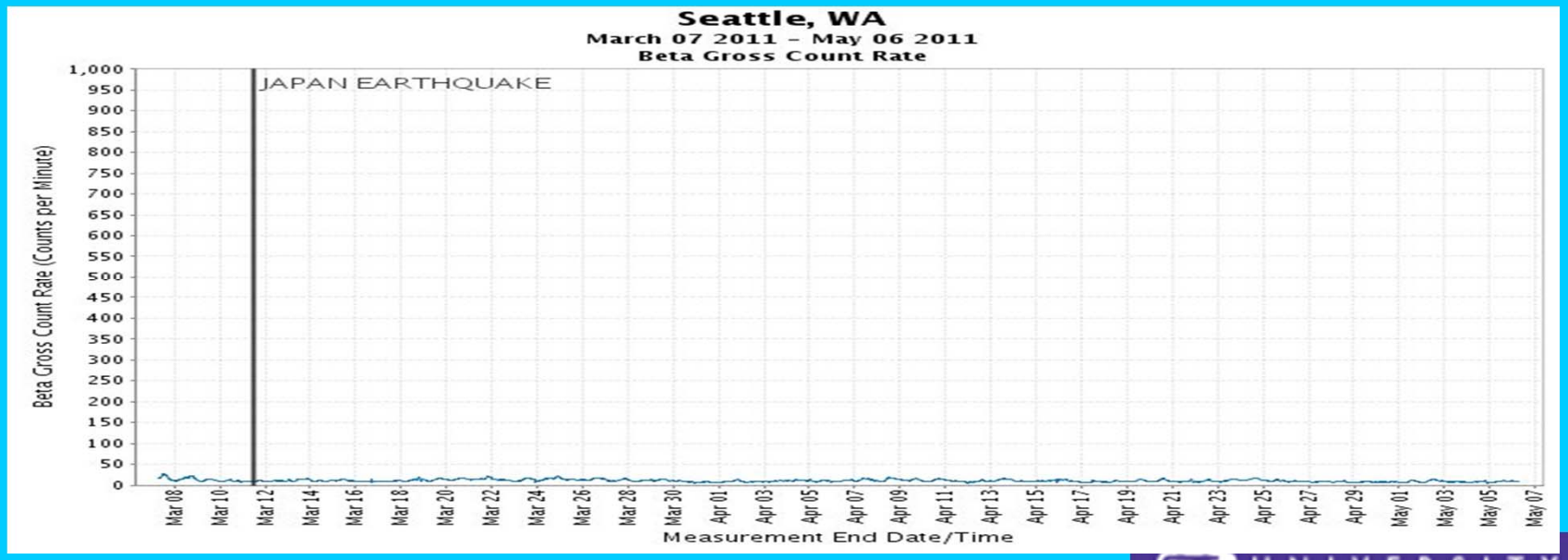
Real time obs in Seatle: Gross gamma/beta





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